PORTABLE ULTRASONIC CLEANER

Field of the Invention

The present invention relates to improvements in convenience devices designed to perform garment cleaning over concentrated areas, and more specifically to a portable device utilizing ultrasonic cleaning and ultraviolet radiation.

Background of the Invention

Portable cleaning devices are known which attempt to physically isolate areas of garment material to perform emergency cleaning or removal of contaminants over a limited area of the garment material. Larger area cleaning is prohibited usually by the limited size of the devices provided, what is hoped to be a limited area of contamination, but more from the prohibitive cost and time associated from wide area cleaning.

Portable cleaning devices are valued for not only their area specificity but for the ability to complete the cleaning process in a short time and to return the soiled garment area to a pre-soiled state and eliminate any indication of the cleaning process. Conventional devices which apply a liquid phase

solvent for removal of the soiled material, even if successful, have the problem of removal of the solvent. Light hydrocarbon solvents can be a health or fire hazard, but water tends to absorb into the garment and can take hours to naturally evaporate.

Another problems with conventional cleaning devices is the use of mechanical scrubbing. Mechanical scrubbing can harm the fabric and cause picks and unraveling. This is particularly true where the soiling is deep and where it is difficult to cause enough movement to enable the solvent to enter and adequately move the soiled mass with respect to the fabric.

Conventional cleaners are almost always mechanical, and none of the small cleaners are available to give even a few of the advantages of larger cleaning systems. Larger cleaning systems, for example include jeweler's ultrasonic bath systems for cleaning fine jewelry in detergents and solvents. These systems utilize a non-portable fixed volume bath which is inappropriate for cleaning small areas of fabric.

Fixed bath type devices are relatively large, on the order of a half to one third of a cubic foot and typically are arranged to ultrasonically shake a stainless steel bath. Inappropriate for travel, these devices would disenable user control of solvent application as any fabric placed in the container would wick fluid into the garment. Further, the

energy consumption from having to energize the metal bath container as well as the whole volume of solution make conventional ultrasonic cleaning reservoirs completely unworkable for cleaning small areas of a garment.

Another problem which can exist with soiled areas is one of odor. In some cases where the soiled material is highly odor laden, and even where virtually all (99.99%) of the soiled material is removed, enough may remain to produce an unpleasant odor. This can be particularly troubling, especially where the cleaning process appears to have been successful. It is important that the cleaned area pass the "smell test", but most portable cleaning devices have no ability to deal with an odor laden residue. Addition of perfumes to mask the odor is unacceptable.

What is needed is a portable cleaning device which (1) enables control of the applied liquid solvent or detergent, (2) can apply direct energy to a soiled area to loosen and removed the soiled material without damage to fabric, (3) include some mechanism to eliminate odors, and (4) supply energy to the remaining solvent in the cleaned area to facilitate its evaporation.

Summary of the Invention

The portable cleaning device of the present invention

utilizes a forward housing which includes an ultrasonic radiator and an ultraviolet radiator. A rearwardly located detergent spray reservoir can be used to optionally apply what may preferably be a dilute solution of soap material. Once solvent is added to the soiled area, the ultrasonic front located area can be placed in contact with the wetted garment area and energized to bring the ultrasonic radiator into direct contact with the solution in contact with the soiled area. This enables less energy to be utilized due to the close proximity to a limited liquid volume in the immediate area of the fabric and closely co-located with the soiled mass. Actuation of a ultraviolet radiator is activated simultaneously with the actuation of the ultrasonic radiator to begin to help with the odor problem from the outset of the cleaning activity. The combination of ultrasonic and ultraviolet energy input also provides energy to the solvent within the fabric to both increase the efficiency of cleaning and to assist the evaporation of solvent. The portable cleaning device can also be utilized with other solvents supplied by the user.

Brief Description of the Drawings

The invention, its configuration, construction, and operation will be best further described in the following detailed description, taken in conjunction with the accompanying

drawings in which:

Figure 1 is a perspective view of the housing of the portable ultrasonic cleaner illustrating a forward balanced radiator section and rear handle with control panel;

Figure 2 is a side sectional view, taken along line 2-2 of Figure 1 and illustrating the arrangement of the ultrasonic transmission member and a pair of flanking ultraviolet light pipes;

Figure 3 is a front view of the structures of the detachable cap seen in Figure 2;

Figure 4 is an overall block diagram of the circuitry of the portable ultrasonic cleaner;

Figure 5 is a detailed diagram of the transducer driver circuit and transducer; and

Figure 6 illustrates the portable ultrasonic cleaner of Figurs 1 - 5 used with a small reservoir of fluid.

Detailed Description of the Preferred Embodiment

The description and operation of the invention will be best initiated with reference to Figure 1 and which illustrates a portable ultrasonic cleaner 11 as an integrated unit having a rear housing section 13 and a front housing section 15. The rear housing section 13 is shaped for comfortable one-hand utilization, and includes a control panel 17 and may have an

on/off switch 19 and power indicator 21.

The lower area of the rear housing section 13 may have an optional solvent/detergent spray nozzle 23 actuated by a pump handle 25. Other methods of delivery of fluid media may be utilized, and the overall area of the portable ultrasonic cleaner housing may be reduced with the optional elimination of the lower solvent/detergent reservoir and delivery mechanism.

The front housing section 15 includes a detachable cap 27 to facilitate cleaning and service of the working face components should these components be contaminated by solvent, detergent, or other materials. At the front of the detachable cap 27 is seen a central ultrasonic radiator 31, flanked by a pair of light pipe structures 33 and 35 which are in optical alignment with ultraviolet light generators within the front housing section 15.

The proximity of the pair of light pipe structures 33 and 35 with respect to the central ultrasonic radiator 31 enables simultaneity of action by bringing a front face 37 of cap 27 into contact with a portion of the fabric to be cleaned. Front face 37 is typically the engagement face which will be in contact with the area of soiled fabric to be cleaned, but the shape of the portion of the portable ultrasonic cleaner 11 placed in fluid contact with a soiled fabric area may differ drastically from the flat frontal profile of the front face 37.

The central ultrasonic radiator 31 protrudes slightly forward of the pair of light pipe structures 33 and 35 to facilitate contact with a section of cloth or a section of a garment which has been soiled.

It should be kept in mind that fluid contact with the central ultrasonic radiator 31 is generally necessary to insure transmission of the ultrasonic energy into the area of the garment which is soiled. Fabrics sections which are not wetted will tend to absorb or insulate the ultrasonic energy from cleaning action on the debris and will generally insulate the interior of the cloth material from ultrasonic shaking action.

The use of the portable ultrasonic cleaner 11 in accord with the configuration shown in Figure 1 involves first removing any soiling or debris which can be physically lifted off of the contaminated fabric area to minimize the cleaning an blotting action which will be needed. Once the excess physically removable debris has been cleared, the debris or soiling area is wetted with an appropriate fluid.

In general, a weak, water based detergent should be used for most types of cloth, especially where the soiling or debris is organic and non polar, and where the fabric will not be dissolved or discolored by the detergent. A weak soap solution will work best with most fabrics and because it will not be present in the cleaning fluid in a concentration so high that it

leave a residue after blotting or after evaporation of the base solvent.

Other solvents may be used, especially in the case where a well known contaminant is known to be dissolved or loosened by a known solvent, but where the solvent will not negatively affect the material. Care should also be taken not to use solvents which might harm the front face 37 of cap 27. Where other solvents are used, the user should take care to use the portable ultrasonic cleaner 11 in well ventilated areas and in a safe manner.

After the debris laden area of the fabric is wetted, the portable ultrasonic cleaner 11 is turned on and the front face 37 of cap 27 is placed against the debris area so that central ultrasonic radiator 31 is brought into intimate contact with the central wet area of the applied solvent or detergent to cause the ultrasonic energy to permeate through the wetted volume. Inasmuch as the wetted material area is likely to assume a circular shape and whereas the central ultrasonic radiator 31 has a rectangular shaped face, the user will want to turn and manipulate the portable ultrasonic cleaner 11 to make sure that all surface areas of the wetted solvent or detergent are contacted by the face of the central ultrasonic radiator 31.

Next, the solvent or detergent with suspended debris may be blotted to attempt to draw off both. The soiled area can then

be re-wetted with solvent or detergent, and the above the steps repeated until the debris or soiled material is completely removed. After removal to an acceptable level or until it is visually imperceptible, the portable ultrasonic cleaner 11 is left on and the front face 37 of cap 27 is continued to be placed against the debris area so that (1) ultrasonic energy continues to enter the just-blotted area of fabric, and so that (2) ultraviolet energy from the pair of light pipe structures 33 and 35 can continue to enter even more deeply into the previously soiled, but now drying area of fabric. The continuation of both ultrasonic and ultraviolet energy will quicken the drying time for the area of fabric just cleaned. The effectiveness of the ultraviolet energy will increase with increased drying of the fabric area due to reduced attenuation of the ultraviolet energy through solvent, detergent, and possibly suspended debris, along with the ability for ultraviolet light to directly impinge on any debris residue remaining in trace amounts.

The ultrasonic energy input also "shakes" the fabric material to insure that any remaining debris residue is more completely exposed to the ultraviolet light for reaction, destruction and accompanying odor elimination. Thus, continued treatment enables a safe and odor fighting energy input which will contribute to odor free drying and hasten the completion of

the cleaning operation.

Referring to Figure 2, a side sectional view of the front housing section 15 shows one possible configuration of the central ultrasonic radiator 31 and its relationship to a pair of light pipe structures 33 and 35. An ultraviolet light emitting diode 39 is adjacent to and oriented to direct ultraviolet light into light pipe structure 33 and ultraviolet light emitting diode 41 is adjacent to and oriented to direct ultraviolet light into light pipe structure 35. It is contemplated that light pipe structures 33 and 35 will each accommodate a pair or more of ultraviolet emitting diodes like diodes 39 and 41. Electrical lines 43 are shown electrically connected to the diodes 39 and 41.

The central ultrasonic radiator 31 is shown as a large monolithic structure, but need not be. The size and orientation of the central ultrasonic radiator 31 will depend upon how it connects to a piezoelectric member. The mass of the central ultrasonic radiator 31 and the support mass of any other member supporting a piezoelectric member, as well as the frequency of operation will determine these members, their orientation and mass.

Referring to Figure 3, a front view of the detachable cap 27 and its structures seen in Figure 2 are illustrated. Also seen is an upper key projection 43 is seen which fits into a

complementary slot in the front housing section 15.

The internal electrical structure of the portable ultrasonic cleaner 11 will more effectively explored with reference to Figure 4 which illustrates an electrical block diagram. A DC INPUT block 51 can be represented by an internally located alternating current transformer and direct current conversion circuitry, or by an external direct current power cord, or by batteries internally located with respect to the portable ultrasonic cleaner 11. The extent to which the portable ultrasonic cleaner 11 accommodates either batteries within or outside its housing or an AC to DC power supply in a connector system or inside the housing will largely be driven by the need to miniaturize the portable ultrasonic cleaner 11, and the need to supply more or less power. The central ultrasonic radiator 31 and pair of light pipe structures 33 and 35 can be provided in multiple numbers and of higher or lower power, and of larger or smaller area, as an example.

The DC INPUT block 51 may be supplied directly to a UV LEDS block 53 or via an independently switched control. The a UV LEDS block 53 can represent a bank of ultraviolet light generating diodes. As can be seen from Figure 1, the pair of light pipe structures 33 and 35 are used to isolate the actual electronic light producing members from the wetted fabric. The number and intensity of the actual electronic light producing

members will need to be matched to the actual electronic light producing members from the wetted fabric.

The DC INPUT block 51 also supplies power to a POWER CONTROL CIRCUIT block 55 which controls the pulsing or timing of power to a TRANSDUCER DRIVER block 57. The TRANSDUCER DRIVER block 57 includes circuitry to convert the instructional master signal from the POWER CONTROL CIRCUIT block 55 into the raw impulse power necessary to drive TRANSDUCER block 59. TRANSDUCER block 59 typically includes the analog piezoelectric elements which are physically connected to the central ultrasonic radiator 31.

Referring to Figure 5, a schematic view of the circuitry of POWER CONTROL CIRCUIT block 55, TRANSDUCER DRIVER block 57 and TRANSDUCER block 59 are shown. From a 12 volt direct current input, the circuitry extends down to an integrated circuit U1, and is connected directly to the terminals 4 (R input) and 8 (Vcc input) of integrated circuit U1 and through a Resistor R9 to terminal 7 (DIS) of integrated circuit U1. Terminal 7 (DIS) of integrated circuit U1 is connected to terminal 6 (THR) of integrated circuit U1 through a current input of a diode D6. Terminal 8 of integrated circuit U1 is connected to terminal 7 (DIS) of integrated circuit U1 through a series combination of resistor R8 and a current input of a diode D7.

Terminals 6 (THR) and 2 (TRIG) of integrated circuit U1 are connected together and to ground through a capacitor C8. Terminal 5 (Cvolt) of integrated circuit U1 is left free floating, and the ground terminal GND is grounded. A timing signal is output through terminal 3 (Q output) through a resistor R7 and into the base of a transistor Q3. The collector of transistor Q3 is connected to the 12 volt input and to ground through a parallel combination of capacitors C3 and C2. The emitter of transistor Q3 is connected through a resistor R1 to a coil 3-2 of a transformer T1 and to the base of a transistor Q2. The other end of coil 3-2 is connected to the base of a transistor Q1.

The collector of transistor Q2 is connected to one end of coil 5-6 of transformer T1, the other end of coil 5-6 is connected to the collector of transistor Q3. The emitter of transistor Q2 is connected to the collector of transistor Q1 and to ground through an inductor L1. The emitter of transistor Q1 is connected to a coil 7-6 of transistor T1 and to the collector of transistor Q2 through a capacitor C5. The other side of transistor T1 is shown as having a coil 1-4 which has a first end connected through a parallel combination of capacitor C1 and piezoelectric element Y1 to a second end of coil 1-4. Second end of coil 1-4 is grounded.

The 12 volt DC input is also shown as connected through an

optional switch S1, a resistor R10 and a series connected set of ultraviolet light emitting diodes LED1, LED2, LED3, and LED4, to ground. The switch S1 may be used to independently control the ultraviolet light emitting diodes LED1, LED2, LED3, and LED4, or the 12 DC power may be independently controlled upstream without switch S1 so that the ultrasonic circuitry is energized at the same time as the ultraviolet light emitting diodes LED1, LED2, LED3, and LED4. The values for the foregoing electronic components are shown in Table I.

Table I

Q1	??
Q2	??
Q3	??
C1	0.0 microfarad
C2	0.0 microfarad
C3	0.0 microfarad
C5	0.0 microfarad
C8	0.0 microfarad
R7	0.0 ohms
R8	0.0 ohms
R9	0.0 ohms
R10	0.0 ohms
Y1	area?size?part NO.?
Q1	part no.
Q2	part no.
Q3	part no.
L1	0.0 Henrys
LED1,2,3,4	Part No.

Referring to Figure 6, a further use possibility for the portable ultrasonic cleaner 11 is the placement of the detachable cap 27 portion of the portable ultrasonic cleaner 11

into a small reservoir 61 having a fluid level 63 to enable users to clean objects placed in the reservoir 61. This enables the portable ultrasonic cleaner 11 to also be used to clean small objects such as rings and the like. The portable ultrasonic cleaner 11 need only be placed below the fluid level 63 sufficiently to enable the central ultrasonic radiator 31 to make contact with the fluid in the reservoir. Over-submersion should be avoided, and a flexible barrier against the front face 37 of cap 27 may be used.

Although the invention has been derived with reference to particular illustrative embodiments thereof, many changes and modifications of the invention may become apparent to those skilled in the art without departing from the spirit and scope of the invention. Therefore, included within the patent warranted hereon are all such changes and modifications as may reasonably and properly be included within the scope of this contribution to the art.